

Emergency Neurologic Examination

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1.1 Introduction

The human nervous system contains more than 100 billion neurons. Each has a unique function enabling taste, smell, touch, sight, hearing, movement, respiration, cognition, and much more. In the setting of a neurologic emergency, patients may lose these unique capacities. It is the emergency physician's responsibility to complete a neurologic history and examination to determine the type of deficit and the neuroanatomical location of the abnormality.

A unique aspect of neurology is that anatomical localization of lesions is of paramount importance. Localizing lesions is a multiphase process: The initial history, general physical examination, and neurological examination integrate symptoms and signs that provide clues to the suspected anatomical location of the abnormality. This localization of neuroanatomical abnormality informs an ordinal ranked differential diagnosis. If the localization process suggests multiple lesions in the nervous system, the implications of each lesion are considered separately and in combination. It is often said that neurologic diagnosis is based 90% on history and 10% on examination. Prior to examining the patient, the physician often has a clear understanding of likely disease processes to explain the patient's chief complaint from the history alone.

A comprehensive neurologic examination is often impractical in the emergency setting and therefore an examination targeted to the patient's presenting symptoms and neurologic deficits is required. If a patient presents with a fever, confusion, and generalized weakness, the primary considerations are very different than those of a patient who presents with sudden-onset aphasia and right hemiparesis. In the first example, the history and physical examination aim to uncover clues involving multiple organ systems that may point to infection or toxic-metabolic syndromes. The second example points to a primary neurologic disease process, but the emergency physician must explore all of the possibilities for systemic disease that may also contribute. The goal of the emergency department (ED) neurologic evaluation is to determine if a neurologic condition exists, to identify possible causes, to intervene in a timely fashion, and to establish the proper disposition of the patient.

The stepwise process of the ED neurologic evaluation is:

1. Identify and characterize the neurologic symptoms (e.g., loss of sensation, ataxia, weakness, aphasia) through a detailed history.
2. Complete an initial neurologic examination (mental status, cranial nerves, motor, sensation, and reflexes) focusing on relevant symptoms.
3. Localize the lesion(s) (central or peripheral: focal, multifocal, or diffuse).

4. Generate a differential diagnosis in the order of the most likely to the least likely consideration.
5. Determine a diagnostic plan with appropriate testing as directed by the differential diagnosis and order consultations as indicated.
6. Initiate treatment when there is clinical urgency.
7. Determine disposition from the ED.

1.2 History

A thorough history is key to determining the cause of neurologic disease or dysfunction and making an accurate diagnosis in the ED. It is also a useful tool to evaluate the patient's mental status by their presentation of the history of their present illness. While obtaining the neurologic history, the physician may also assess the patient's speech, mood, affect, and general appearance. A bystander or family member's description of the patient's behavior is often helpful in making a diagnosis. Obtaining a detailed neurologic history is essential to determine the anatomic localization, tailor the differential diagnosis, and streamline the neurologic examination.

1.3 Key Elements of a Focused Neurologic History

1. Symptoms (location, quality, radiation, severity)
2. Onset (exact time of onset, precipitating events, last time known normal)
3. Duration (minutes, hours, days, intermittent, chronic)
4. Progression (slowly progressing, acute onset, gradual resolution, intermittent)
5. Associated symptoms (recent illness, fever, headache, trauma, loss of consciousness)
6. Aggravating or alleviating factors (movement, hot or cold, light)
7. Distribution of process (unilateral, bilateral, dermatomal)
8. Medical history (previous episodes, medication use or ingestions, occupation, family history)

After obtaining a thorough neurologic history and performing a neurologic examination, physicians should not hesitate to revisit and refine the patient's neurologic history. Examination findings may change the understanding of the case and create new questions for the patient and family members.

1.4 Neurologic Examination

The neurologic examination is a bedside tool that helps to localize the origin of the patient's symptoms to either the central or peripheral nervous system. This includes assessment of the patient's mental status, language, cranial nerves, sensory and motor function, and reflexes. A complete neurologic examination in the emergency setting is often neither necessary nor appropriate given the time constraints and the rapidity with which a diagnosis must be made. Therefore, a neurologic examination tailored to the patient's history and symptoms is most useful.

1.5 Brief Neurologic Examination

1. Mental status (assessed through history-taking, concise mental status examination, and/or Glasgow Coma Score in altered patients)
2. Cranial nerve function
3. Motor function

4. Sensation
5. Coordination and balance
6. Reflexes (both deep tendon and pathologic)

Video 1.1: Emergency Neurologic Exam. Video 1.1 can be accessed at <http://www.cambridge.org/campbellkelly>

1.6 Mental Status

Mental status is a key part of the neurologic examination as it frequently impacts the patient's ability to cooperate with evaluation. Consider the patient's general appearance, behavior, attention, orientation, speech, dress, memory, mood, affect, and attitude. Is the patient disheveled? Do they have rapid pressured speech? Do they require constant stimulation or are they able to carry on a normal conversation? If there is evidence of severe encephalopathy, the patient is unlikely to be able to follow commands and participate in a thorough assessment of strength and sensory function. If they are able to provide information about their medical history and the history of present illness clearly and in a consistent manner, then they have normal mental status. If not, then a more thorough mental status examination is necessary and there are tools such as the OMIHAT Mnemonic (Table 1.1) or the Mini-Mental Status Exam. In altered patients, the Glasgow Coma Scale (GCS) (Table 1.2) may be the best assessment tool to assess responsiveness and mental status.

1.6.1 Cranial Nerves

Evaluation of cranial nerves II–XII can be completed in a few simple steps:

Check visual acuity, pupillary light reflex, and visual fields (CN II).

Look for ptosis and evaluate ocular motion, conjugate gaze, and nystagmus by asking the patient to follow a target moved in the shape of an “H” with only their eyes (CN III, IV, VI).

Softly touch the face in the three divisions of the trigeminal nerve bilaterally (CN V).

Ask the patient to smile, raise their eyebrows, shut their eyes, and puff out their cheeks (CN VII).

Evaluate hearing bilaterally with whispered word or finger rub (CN VIII).

Assess for gag reflex and ensure that the uvula is midline (CN IX, X).

Have the patient shrug their shoulders and turn their head against resistance (CN XI) and protrude and move the tongue (CN XII).

Table 1.1 Rapid Mental Status Exam
OMIHAT

O	Orientation
M	Memory
I	Intellect
H	Hallucinations
A	Affect
T	Thought

Table 1.2 Glasgow Coma Scale

Eye opening	Spontaneously	4
	To verbal command	3
	To pain	2
	Do not open	1
Verbal response	Alert and oriented	5
	Disoriented	4
	Nonsensical speech	3
	Unintelligible	2
	Unresponsive	1
Motor response	Follows commands	6
	Localizes pain	5
	Withdraws from pain	4
	Decorticate flexion	3
	Decerebrate extension	2
	No response	1
Total score		3–15

1.6.2 Motor Examination

The motor examination can be difficult if movement is limited by pain or if the patient is uncooperative. If the patient is able to walk, evaluation of the patient's gait can be very helpful. If the patient is unable to ambulate, assess pronator drift to identify subtle weakness of the upper extremities. To do so, ask the patient to hold their arms out, palms up, for 10 seconds. If pronation and downward drift occurs, this indicates motor weakness. Test the strength of several muscle groups and record the strength assessment with a five-point scale (Table 1.3).

Proceed head to toe, examining strength at multiple levels (deltoid flexion, biceps flexion, wrist extension/flexion, bilateral grip strength). In the lower extremities, test hip flexion, knee extension/flexion, and ankle dorsi/plantar flexion to evaluate strength bilaterally.

1.6.3 Sensory Examination

Sensory findings are difficult to interpret particularly during a concise ED examination. Traditionally, a full sensory evaluation is done by examining light touch, pinprick, position sense, vibration, temperature, and pain. Evaluate sensation in a rapid fashion in the ED by asking a patient to close their eyes and identify simple letters or numbers written on the palm of their hand. A cooperative patient can be asked to outline the area of sensory deficit or change. There are many references to use on your phone, Internet, or text to identify the dermatome assigned to the symptoms as detailed in Table 1.4.

Table 1.3 Five-point scale for muscle strength testing

5 = normal strength
4 = movement against some resistance
3 = movement against gravity
2 = unable to move against gravity
1 = muscles contract, but no motion follows
0 = no muscle contraction

Table 1.4 Sensory examination and dermatomes

Cervical nerves and their dermatomes
C2: the base of the skull and behind the ear
C3: the back of the head and the upper neck
C4: the lower neck and upper shoulders
C5: the upper shoulders and the two collarbones
C6: the upper forearms, thumbs, and index fingers
C7: the upper back, back of the arms, and middle fingers
C8: the upper back, inner arms, and ring and pinky fingers
Thoracic nerves and their dermatomes
T1: the upper chest, back, and upper forearm
T2, T3, and T4: the upper chest and back
T5, T6, and T7: the mid-chest and back
T8 and T9: the upper abdomen and mid-back
T10: the midline on the abdomen and the mid-back
T11 and T12: the lower abdomen and mid-back
Lumbar nerves and their dermatomes
L1: the groin, upper hips, and lower back
L2: the lower back, hips, and tops of the inner thighs
L3: the lower back, inner thighs, and inner legs just below the knees
L4: the backs of the knees, inner sections of the lower legs, and the heels
L5: the tops of the feet and the fronts of the lower legs
Sacral nerves and their dermatomes
S1: the lower back, buttocks, backs of the legs, and the outer toes
S2: the buttocks, genitals, backs of the legs, and heels
S3: the buttocks and genitals
S4 and S5: the buttocks

1.7 Reflexes

Reflex testing is an objective method to test patency of simple neural connectivity from the periphery to the spinal cord to the effector muscle. To test deep tendon reflexes (DTRs) – actually, muscle stretch reflexes (MSRs) – the limb should be relaxed and in a symmetric

Table 1.5 Muscle stretch reflexes

Biceps	C5–C6
Supinator brachioradialis	C6
Triceps	C7
Knee	L4
Ankle	S1
Cutaneous reflexes	
Abdominal – upper umbilicus	T8–T10
Abdominal – lower umbilicus	T10–T12
Cremasteric	L1–L2
Anal	S2–S5

position. Check one side and then immediately compare the reflex response with that of the contralateral side. Reflexes are graded on a scale of 0–4: no reflex elicited (0), hypoactive reflexes (1), normal reflexes (2), hyperactive reflexes (3), and clonic reflexes (4). Reflexes graded 1–3 are not considered to be abnormal. However, clonus, gross asymmetry between arms and legs or a substantial difference between contralateral sides should warrant further investigation. Many conditions such as age, electrolyte abnormalities, thyroid dysfunction, toxic ingestions, diabetes, and even anxiety can influence reflexes. However, testing the biceps (C5–C6), brachioradialis (C6), triceps (C7), patellar (L4), and Achilles (S1) tendons can help to identify the spinal nerve roots involved in a particular injury (Table 1.5).

It is also important to check for pathologic reflexes. The Babinski reflex can be elicited by running a dull object (such as a pen) up the lateral aspect of the plantar surface of the foot to the toe. If an extensor plantar response is obtained (i.e., an “up-going toe”) this indicates an upper motor neuron lesion.

The absence of normal cutaneous reflexes such as the anal wink or perineal reflex (S2–S4) and cremasteric reflex (L1–L2) can be helpful in identifying pathology, such as a conus medullaris or cauda equina lesion or an epidural hematoma.

1.7.1 Coordination and Balance

The ability of the body to balance and coordinate movement is referred to as equilibrium. If the patient exhibits ataxia, has difficulty with tandem gait, or has a positive Romberg sign, this indicates disequilibrium. Truncal ataxia is recognized by a wide-based gait and poor balance while sitting or standing. Limb ataxia can be identified by testing the finger–nose–finger and heel–knee–shin movements of bilateral upper and lower extremities, respectively. Ataxia, tremor, and impairment of rapid alternating hand movements are classic indicators of cerebellar lesions.

1.7.2 Language

Dysarthria and aphasia are the two most common speech abnormalities. Dysarthria is caused by a deficit in the motor production of speech. Slurring of words may be caused by oral or facial

lesions as well as central lesions affecting the posterior circulation or neurologic disorders such as multiple sclerosis, Parkinson's disease, or amyotrophic lateral sclerosis.

Aphasia arises from injury to the language centers of the brain resulting in disordered communication. Aphasia is characterized by the inability to speak, read, write, or comprehend. Aphasia is most frequently caused by stroke, traumatic brain injuries, tumors, or progressive neurologic disorders. During the history and physical examination, it is critical to determine the onset, progression, and type of aphasia (either receptive or expressive) as these will provide strong clues to localize the disease process.

1.7.3 Using the Results of the Neurological Exam

The findings of the neurologic examination must be incorporated in the context of the patient's overall history and general physical examination to determine the appropriate course of investigation (e.g., CT, MRI, lumbar puncture) and to rapidly determine the most appropriate therapy (e.g., hydration, antibiotics, transfusion, TPA) to treat the disease. Physicians should expand upon specific elements of the history and physical examination as the stepwise process unfolds. Physicians often need to return to the bedside to perform more detailed examinations as part of the diagnostic process and rapidly evolving symptoms often require repeating the examination at regular intervals.

Pearls and Pitfalls

- History is critical and should be obtained in all manners possible, including the patient, family, friends, and electronic records, and often requires repeated attempts.
- Similar to the history, serial examinations are critical to determine any rapid changes or progression of abnormal neurologic signs.
- The chaotic environment of the ED may necessitate interrupted evaluations and it is important not to forget the progression of the evaluation.
- History-taking and the neurologic examination are as important as, and often more so than, imaging studies, which should not be considered a replacement for a thorough history and examination.

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